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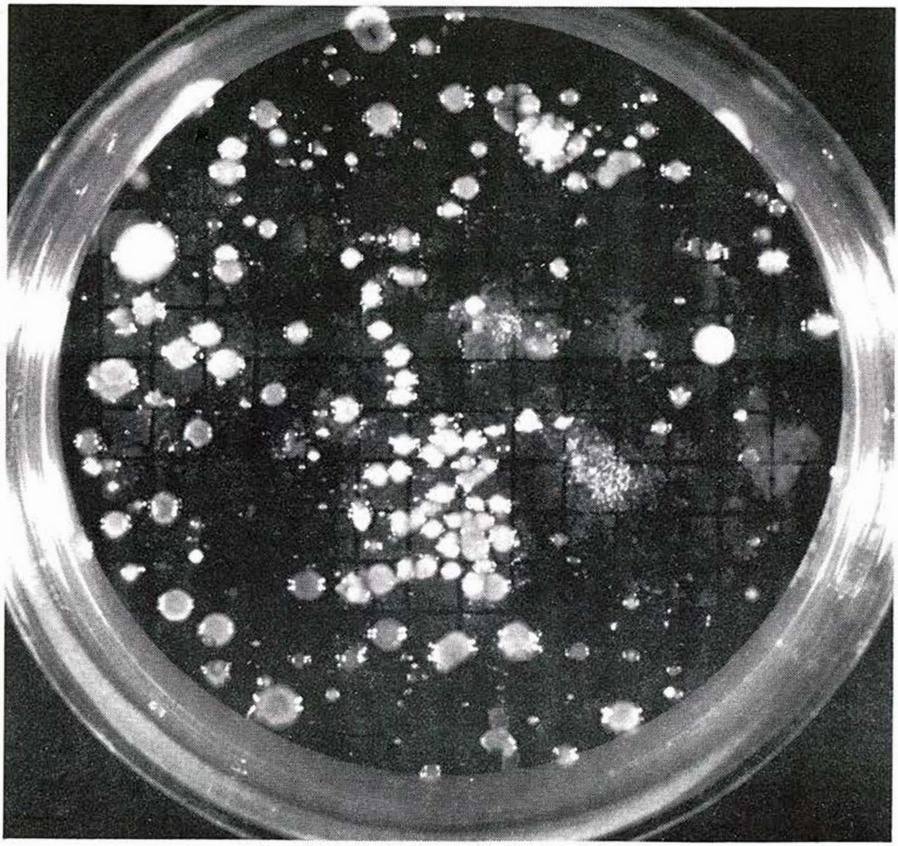
Spruce Budworms Handbook

Regional Evaluation of B.t. for Spruce Budworm Control



In 1977, the United States Department of Agriculture and the Canada Department of the Environment agreed to cooperate in an expanded and accelerated research and development effort, the Canada/United States Spruce Budworms Program (CANUSA), aimed at the spruce budworm in the East and the western spruce budworm in the West. The objective of CANUSA was to design and evaluate strategies for controlling the spruce budworms and managing budworm-susceptible forests, to help forest managers attain their objectives in an economically and environmentally acceptable manner. The work reported in this publication was wholly or partially funded by the Program. This manual is one in a series on the spruce budworm.

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Canada
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Spruce Budworms
Program

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Regional Evaluation of B.t. for Spruce Budworm Control

by D. G. Grimble and O.N. Morris[1]

The Problem

The spruce budworm is currently at outbreak levels across millions of acres of spruce-fir forests of Eastern North America. The effects of repeated defoliation by the voracious caterpillars have killed large numbers of spruce and fir trees needed by wood-using industries. To protect their forests, managers in Maine and Canada have resorted to repeated, large-scale spray programs aimed at keeping the trees alive until they can be harvested, or until the insects "go away." For the most part, synthetic chemical insecticides are used even though forest managers would prefer control measures safer for the environment. Various formulations of *Bacillus thuringiensis* (B.t.), an environmentally acceptable microbial insecticide, are available but have not been widely used for budworm suppression projects. B.t. is used to spray in environmentally sensitive areas or where chemical insecticides are not allowed.

B.t. is a naturally occurring bacterium that kills many species of caterpillars without harming other types of organisms in the forest. B.t. is currently the only biological spray material available for budworm suppression, but chemicals are the preferred treatment because they are lower in cost and often more effective than B.t.

On a per-acre application basis, B.t. often costs more than chemicals. This is an important consideration when planning large suppression projects involving millions of acres. Just as important, however, is the confidence the manager has that the sprays will successfully control the pest and protect the trees. Here, too, B.t. has been at a disadvantage. It kills more slowly than chemicals and seems to be more affected by adverse weather. Generally, B.t. can be sprayed effectively over a shorter time period and at lower maximum budworm density than chemicals. Also, various forest protection agencies using B.t. have reported conflicting and inconsistent results—excellent control in some instances and poor control in others, usually where weather, spray timing, larval populations, or application were not optimum. Chemical insecticides also fail to give satisfactory results at times, but these failures are not as widely publicized. Managers are not convinced that B.t. is consistently effective enough to pay the higher price for the product.

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Regional Evaluation

Many CANUSA investigators believed that if B.t. spray treatments were monitored on a regional basis, rather than as individual spray block(s), the most common causes for poor results might be more apparent, indicating where research emphasis should be placed. Further, regional evaluation of many B.t. treatments might demonstrate that the B.t. success rate was actually higher than commonly believed and that this biological spray could be relied on for successful control under reasonable conditions.

B.t. was being used operationally each year in Maine and the Maritime Provinces of eastern Canada (fig. 1), and regional representatives met in spring 1979 to consider data collection so the results of B.t. use in the different locations could be compared. All agreed to collect specific common data from a portion of their B.t.-treated forest lands and transmit those data to the Forest Pest Management Institute in Sault Ste. Marie, Ont., for analysis. Data were collected during the 1979 and 1980 spray seasons in Maine, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland. All major forestry-use

Figure 1—Aerially applied B.t. is used to prevent defoliation of fir trees by spruce budworm. Ontario. 1980. Helium balloon indicates spray block boundary. (Photo by O. N. Morris. Canadian Forestry Service.)

B.t. commercial products—Dipel® (Abbott Laboratories), Thuricide® (Sandoz, Inc.), and Novabac® (Nutralite, Inc.)—were involved in the regional evaluation.[2] The brand used was chosen by the responsible officials at each location. When analyzed on a regional basis, the efficacy data led to some interesting conclusions.

Spray deposits were estimated by examining or culturing Kromekote® spray cards, millipore filters, or glass plates placed in spray blocks before treatment was begun. Samples of the concentrated B.t. in shipment drums and of mixed spray formulations were bioassayed to detect significant divergence in potency or concentrations from the labeled potency. Although the major results and conclusions of this regional effort are summarized here, readers who desire further information are encouraged to consult the detailed original report (Morris 1981).

Comparative Results

This was the first regional comparison of common data from many geographically widespread B.t. applications, all done in the same spray seasons. It proved to be an effective tool for making comparisons not normally possible. Although the final results of spraying any particular tract of budworm-infested forest land depend upon many factors unique to the time and place, regional evaluation of B.t. did bring out several important trends.

Effectiveness

Efficacy data were collected from 62 spray blocks of variable size, encompassing about 358,078 acres (144,970 ha) (table 1). If defoliation in a particular spray block was limited to 50 percent or less of the current year's needles, the spraying was considered successful. By that standard, table 1 shows that a generally high level of effectiveness was achieved with both formulations most frequently used in operational programs—Thuricide 16B and Dipel 88 (4L). The percentage of successes was nearly identical: 71 and 69 percent, respectively, of the acreage treated with these formulations in 1979 or 1980 met the standard. Failures, measured by inadequate foliage protection, were believed due to poor weather conditions, extremely high population densities of budworm larvae (over 30 larve/18-inch [45-cm] branch tip), or simply less vigorous spruce/fir in the spray block. Trees with poor vigor have less foliage to intercept spray droplets; having fewer needles, such trees are more quickly defoliated. Further, data from Maine and Quebec showed that when B.t. was applied at a

[2] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Table 1—Success rates of various B.t. products used to suppress the spruce budworm in eastern Canada and Maine, 1979-80[1]

Commercial product	Acres treated 1979-80	Number of locations	Percent of treated area protected[2]
Thuricide 16B	202,629	31	71
Thuricide 24B	939	5	47
Thuricide 32B	63,941	5	81
Dipel 88 (4L)	76,694	15	69
Dipel 45B	198	1	100
Novabac 3	13,479	4	82
Novabac 45B	198	1	100

[1]For metric conversions, use this equivalent: 1 ha = 2.471 acres.
[2]Defoliation limited to 50 percent or less of current year's growth. Some areas received more than the standard treatment of 8 BIU/acre.

heavy dosage rate (12 billion international units [BIU]/acre, or 30 BIU/ha), foliage protection during 1981 was comparable to that from chemical sprays[3] (Morris 1981).

The density of budworm larvae on tree foliage also has a large influence on whether the B.t. sprays will protect that foliage. B.t. requires a few days to kill budworm larvae. If larvae are too numerous, all of the needles may be consumed before the pests are killed. Generally, treatments were most successful when larval density was less than 30 per 18-inch (45-cm) branch tip and the trees still had plentiful foliage.

[3]Trial, H. Preliminary results: Maine spruce budworm suppression project—1981. Unpublished report. Augusta, ME: Maine Forest Service; 1981. 14 p.

Treatment Costs

The average cost of B.t. spraying—spray materials and application (8 BIU/acre) only—during 1980 ranged from $8.45 to $16.73 per acre:

Newfoundland and Labrador	$ 8.45(Can.)/acre
Ontario	9.62(Can.)/acre
Maine	12.50(U.S.)/acre
Nova Scotia	16.73(Can.)/acre

Because many locations used higher dosages of B.t. or applied the sprays more than once to some spray blocks, or both, only the data for single applications of 8 BIU (a common, "standard" dosage) were compared. Typical costs for using chemical insecticides are usually one-half or less than those for B.t. The lower cost for chemical treat-

ment is due primarily to lower application rates per acre and usually larger treatment blocks, thus, reduced flying time to accomplish the spraying.

Dosage Rates and Spray Deposit

When we first started accumulating data for this study, the standard dosage-volume rate recommended by the manufacturers was 8 BIU of B.t. in 1/2 to 1 gallon of water per acre (20 BIU in 3.8 l water per ha). Under favorable weather conditions and acceptable levels of larval density, this dosage-volume rate was usually sufficient. The regional evaluation data, however, indicate that 8 BIU/acre should be considered marginal in effectiveness and that a more potent (higher BIU) formulation would be more reliable when conditions are less favorable (table 2).

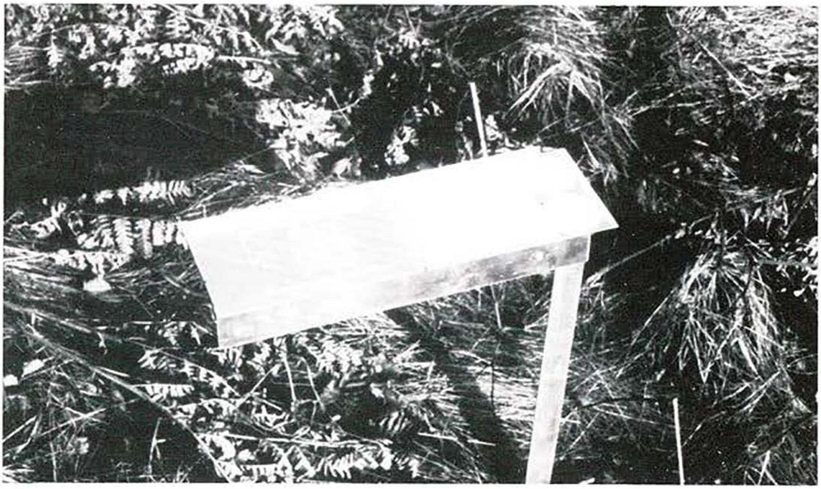
Spray-deposit sampling devices usually are placed on the ground in an opening between trees just before the spray plane passes over the spray block and then retrieved as soon as the spray cloud settles. The number of spray droplets visible on Kromekote cards or colonies of bacteria on cultured millipore filters (fig. 2) indicates the completeness of spray coverage to the block. However, ground deposits often do not bear much relationship to the resultant insect mortality or tree protection. Presumably, measuring deposits on the actual tree needles would be better, but even that would not adequately evaluate the biological activity, or quantity, of bacteria in the droplets.

On the contrary, a trend was apparent in the regional evaluation between spray-deposit estimates and the foliage saved. At densities

Table 2—B.t efficacy in relation to dosage rate of B.t. applied to protect balsam fir in 1979-80[1]

Dosage	Number of acres sprayed	Number of locations	Percent of treated area protected[2]
BIU/acre			
4	13,592	3	85
8	214,058	46	62
12	67,367	3	92
16	198	1	100

[1]For metric conversions, use this equivalent: 1 ha = 2.471 acres.
[2]Defoliation limited to 50 percent or less of current year's growth.



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B

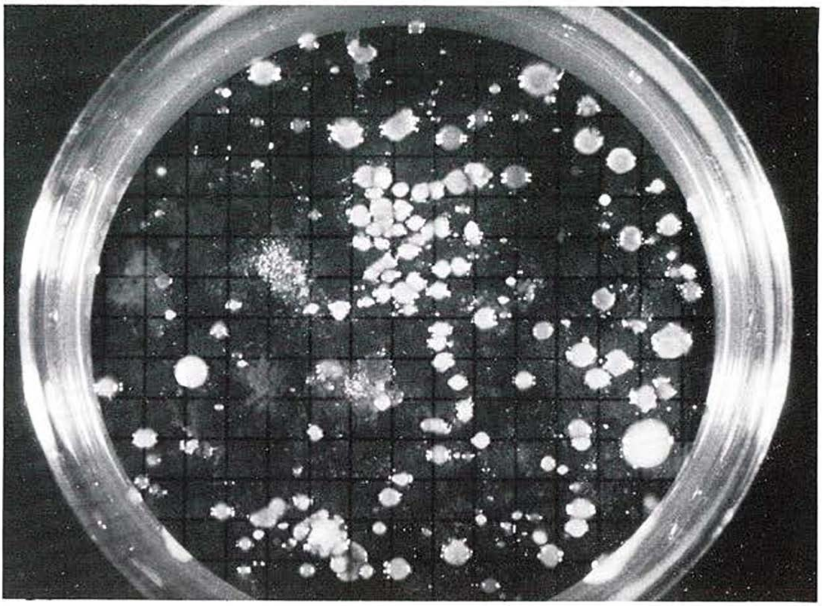

Figure 2—A. B.t. spray deposit sampling device, with glass slides, Kromekote cards, and millipore filters all supported on same stand in spray block. (Photo by O. N. Morris, Canadian Forestry Service.) **B.** Colonies of B.t. on millipore filter after laboratory culturing. (F-532354)

of less than 21 drops per square centimeter of needle surface, foliage protection was inadequate. But at 30 (or more) drops/cm^2, defoliation of balsam fir did not exceed the 50-percent criterion for a successful spray operation (table 3).

Tree Species

Balsam fir is the host tree most damaged by spruce budworms (fig. 3). White spruce, red spruce, and black spruce are also attacked, especially when mixed with balsam fir, but the effects are usually less noticeable on these trees. Many white spruce stands and mixtures of red and black spruce are included each year in the budworm spray operations. Our regional evaluation of the B.t. sprays indicated that the success rate was about 90 percent in white spruce stands and 97 percent in mixtures of red and black spruce (table 4). These figures compare to an overall success rate of about 70 percent for balsam fir. The latter rate reflects the generally higher vulnerability of fir to attack by budworm. Actually, the success rates were remarkably similar for the 2 years monitored: red and black spruce received the best protection each year, followed by white spruce and balsam fir.

Figure 3—Balsam fir tree seriously damaged after complete defoliation by spruce budworm. (Photo by Imre Otvos, Canadian Forestry Service.)

Table 3—Relationship between ground level B.t. deposits and percent protection of balsam fir foliage, 1979 and 1980[1]

Spray droplets per cm²	Total acres treated	Number of spray blocks	Percent of treated area protected[2]
5–10	6,422	7	0
11–20	48,469	11	35
21–30	72,890	8	92
31–40	20,259	4	100
41–50	17,122	4	100
51–87	13,689	2	100

[1]For metric conversions, use this equivalent: 1 ha = 2.471 acres.
[2]Defoliation limited to 50 percent or less of current year's growth.

Table 4.—Success rates for B.t. treatments on different tree species in 1979 and 1980 based upon the proportion of spray blocks acceptably protected[1]

	Acres treated		Percent of treated area protected[2]		
Tree species	1979	1980	1979	1980	Combined
White spruce	52,638	3,487	91	67	90
Red and black spruce	9,188	20,461	95	99	97
Balsam fir	98,079	233,037	69	71	70

[1]For metric conversions, use this equivalent: 1 ha = 2.471 acres.
[2]Defoliation limited to 50 percent or less of current year's growth.

Summary

The cooperation of regional pest control officials in collecting similar data from their own spray programs has allowed the first comparison of B.t. performance over a wide area.

B.t. is the only biological or microbial safe insecticide available for spruce budworm control. Indeed, it is likely to be the only alternative to chemical pesticides in the foreseeable future. B.t. treatments sometimes fail to achieve acceptable results, just as chemical insecticides do, but given reasonable conditions of use, B.t. is usually successful in protecting foliage. At present, B.t. must be considered a viable alternative for chemicals in many situations, especially in environmentally sensitive areas where foliage protection is the goal.

Reference

Morris, O. N. Report on the 1980 cooperative *Bacillus thuringiensis* (B.t.) spray trials. Rep. FPM-X-48. Sault Ste. Marie, ON: Canadian Forestry Service; 1981. 75 p.

Acknowledgments

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